

ICES WGIMT REPORT 2015

SCICOM STEERING GROUP ON ECOSYSTEM PROCESSES AND DYNAMICS

ICES CM 2015/SSGEPD:01

REF. SCICOM

Interim Report of the Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT)

20 March 2015

Plymouth, UK



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Recommended format for purposes of citation:

ICES. 2015. Interim Report of the Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT), 20 March 2015, Plymouth, UK. ICES CM 2015/SSGEPD:01. 27 pp. <https://doi.org/10.17895/ices.pub.8416>

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Executive summary

The ICES Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT) met in association with the 2015 WGZE meeting in Plymouth, UK. The meeting included a joint session with the Working Group on Zooplankton Ecology (WGZE) on 17 March 2015 and a dedicated meeting on 20 March 2015. The primary goals of the meeting were to: 1) review the group's progress on multi-annual ToRs, reports, and recommendations; 2) consider guidelines and suggestions from WGZE; and 3) prepare WGIMT recommendations and plan WGIMT activities for the coming year, including the 2016 annual meeting.

WGIMT membership currently totals 36 members from 15 countries; the continuing growth is consistent with WGIMT ToR (a) to expand membership and welcome new members who develop and use molecular and/or morphological approaches to taxonomic analysis of zooplankton. Progress was reviewed in the continuing development and implementation of the WGIMT web platform for promotion and exchange of relevant scientific information for the morphological, molecular and optical elements [ToR (b)], as well as new elements, including a photo gallery of living zooplankton and literature database. WGIMT has continued work to initiate and support provision of standards, training materials, and taxonomy workshops through organized workshops [ToR (c)]. One workshop, *SAHFOS-MBA Zooplankton Taxonomy Workshop*, exemplifying the WGIMT integrative taxonomic approach was held in June 2015 (Plymouth, UK). Also consistent with ToR (c), WGIMT is supporting the WGZE recommendation that Claudia Castellani and Antonina dos Santos be named as editors of the ICES Zooplankton Identification Leaflets. WGIMT will promote and encourage the continuing integration of molecular and morphological taxonomy by organizing special sessions at national and international conferences, including ICES Zooplankton Production Symposium (2016), ASLO/TOS Ocean Sciences Meeting (2016), among others [ToR (d)]. WGIMT will advise on the implications of developments for marine science and management and will report via SSGEF and ACOM EGs on uses of integrative taxonomy (e.g., environmental sequencing, metabarcoding, or metagenetics) for integrated ecosystem assessment [ToR (e)]. WGIMT will cooperate with WGITMO and WGBOSV to facilitate application of molecular protocols for detection and identification of introduced and transported species in ballast water [ToR (f)]. WGIMT members are publishing peer-reviewed articles on diverse aspects of integrative morphological and molecular taxonomy of zooplankton, and have exceeded the goal of two papers per year; planning is underway for a review article to be published by 2016 [ToR (g)].

Next year, WGIMT proposes to meet in Lisbon, Portugal in association with the annual WGZE meeting, which is planned for March 2016. Additional work will be carried out by correspondence, including videoconferencing.

1 Administrative details

Working Group name:

Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT)

Year of Appointment within the current three-year cycle

2014

Reporting year within the current three-year cycle

2

Chair(s)

Ann Bucklin, USA

Meeting venue(s) and dates

17 & 20 March 2015, Plymouth, UK

2 Terms of Reference a) – z)

- a) Expand membership of WGIMT;
- b) Develop a web platform for promotion and exchange of relevant scientific information;
- c) Initiate and support provision of standards, training materials, and taxonomy workshops;
- d) Promote and encourage the continuing integration of molecular and morphological taxonomy;
- e) Advise on the implications of developments for marine science and management;
- f) Cooperate with WGITMO and WGBOSV to encourage and facilitate application of molecular protocols for detection and identification of introduced and transported species in ballast water;
- g) Publish peer-reviewed articles on diverse aspects of integrative (morphological and molecular) taxonomy of zooplankton.

3 Summary of Work plan

ToR (a) WGIMT will include experts in both morphological and molecular taxonomy for major zooplankton groups; 2 members in common with ACOM EGs (Year 1).

ToR (b)

- 1) WGIMT.net web portal designed, established (Year 1) and fully populated (Year 2).
- 2) Morphological methods: Information and URL links to keys for morphological identification of zooplankton.

- 3) Optical methods: Included in Morphological Methods section or updated.
- 4) Molecular methods: A comprehensive summary of PCR and sequencing primers and protocols and associated references.
- 5) Photo gallery: High-quality images of living zooplankton; photo galleries from the Census of Marine Zooplankton (www.cmarz.org) will be migrated.

ToR (c) SAHFOS-MBA Zooplankton Taxonomy Workshop (2015); ICES Taxonomy Workshop on: *Future of Integrative Taxonomy* (2016).

ToR (d) Organize special sessions at national and international conferences, including Ocean Sciences Meetings (2016), ICES ASC (2016), others.

ToR (e) Report via SSGEPD and ACOM EGs on uses of integrative taxonomy (e.g., environmental sequencing or metagenetics) for integrated ecosystem assessment (Years 2, 3). Report on uses of metagenetic indicators to WGAGFM (Year 2).

ToR (f) Define (Year 1), carry out (Year 2), and publish (Year 3) results of collaborative activities with WGITMO-WGBOSV. Participate in WGITMO-WGBOSV annual meetings (Years 1,2,3). Provide identifying DNA sequences for invasive species listed on AquaNIS (Year 2).

ToR (g) Publish two papers related to WGIMT ToRs (Years 2, 3). Publish review article on integrative taxonomic approaches to characterizing zooplankton communities (Year 2).

4 List of Outcomes and Achievements of the WG in this delivery period

- The WGIMT membership has grown from a total of 22 members as of March, 2013 to a total (as of March 20, 2015) of 36 members from 15 countries
- Further development of the WGIMT web portal was made in three areas: Molecular methods, Photo gallery, and Literature database.

Molecular methods: WGIMT has developed a webpage with a preliminary summary of PCR and sequencing primers and protocols and associated references. A webpage with comprehensive information and additional features is in development; a temporary URL with this information is accessible to WGIMT members to provide comments and suggestions.

Photo gallery: A new feature of the WGIMT portal is a photo gallery of high-quality images of living zooplankton. Selected photo galleries from the Census of Marine Zooplankton (www.cmarz.org) have been migrated to the new area of the WGIMT site. Software will be selected to allow posting and organizing the images for easy access and viewing; images will be cross-linked to WGIMT/WGZE taxonomic database entries (e.g., WGZE time series, geographic maps, and biovolume analyses).

Literature database: A new two-pathway online system for scientific literature relevant to WGIMT is being designed and developed. Public access will include only the reference (for copyrighted materials); password-controlled

access will also have links to downloadable PDFs. A forms-based entry process will allow WGIMT members to upload relevant literature.

- WGIMT members contributed significantly to a successful and productive training workshop, *SAHFOS-MBA Crustacean Zooplankton Taxonomy Workshop*, held in Plymouth, UK during 22–26 June 2015. WGIMT member Claudia Castellani was the lead organizer for the workshop, which was an interactive training course covering classical morphological identification and molecular techniques. More information is available on the SAHFOS website at <http://www.sahfos.ac.uk/zooplankton-2015.aspx>.
- In conjunction with the WGZE, WGIMT members Antonina Dos Santos and Claudia Castellani are leading efforts to update the ICES Zooplankton Identification Leaflets, seeking permission from ICES PUBCOM to serve as editors of the documents, which are currently stored on the ICES website. Among the challenges in this effort is that access to the leaflets is limited because of out-of-date PDF file formats.
- WGIMT member Antonina dos Santos will co-convene an ICES ASC 2015 Theme Session (September 2015; Copenhagen, Denmark); WGIMT member Ann Bucklin will co-chair a session at the ICES/PICES 2016 Zooplankton Production Symposium (May 2016; Bergen, Norway).
- WGIMT is developing a plan for cooperation with WGBOSV/WGITMO to provide identifying DNA sequences for invasive species to be added to the AquaNIS website (see <http://www.corpi.ku.lt/databases/index.php/aquanis/>), which now has a field indicating whether molecular information is available and providing links to primary databases (NCBI GenBank and BOLD).
- Recent publications in the peer-reviewed scientific literature by WGIMT members on topics central to the WGIMT mission more than meet our goal of two papers per year.

2013

- Laakmann, S., G. Gerds, R. Erler, T. Knebelsberger, P. Martinez Arbizu, and M.J. Raupach. 2013. Comparison of molecular species identification for North Sea calanoid copepods (Crustacea) using proteome fingerprints and DNA sequences. *Molec. Ecol. Res.* doi: 10.1111/1755-0998.12139
- Laakmann, S., and S. Holst. 2013. Emphasizing the diversity of North Sea hydromedusae by combined morphological and molecular methods. *J. Plankton Res.* 36: 64–76. doi:10.1093/plankt/ftt078
- Lehtiniemi, M., E. Gorokhova, S. Bolte, H. Haslob, B. Huwer, *et al.* 2013. Distribution and reproduction of the Arctic ctenophore *Mertensia ovum* in the Baltic Sea. *Mar. Ecol. Progr. Ser.* 491: 111–124
- Lindeque, P.K., H.E. Parry, R.A. Harmer, P.J. Somerfield, and A. Atkinson. 2013. Next Generation Sequencing reveals the hidden diversity of zooplankton assemblages. *PLoS ONE* 8: e81327.
- Majaneva, S. and M. Majaneva, 2013. Cydippid ctenophores in the coastal waters of Svalbard: is it only *Mertensia ovum*? *Polar Biol.* doi:10.1007/s00300-013-1377-6

Matzen da Silva, M., A. dos Santos, M.R. Cunha, F.O. Costa, S. Creer, and G.R. Carvalho. 2013. Investigating the molecular systematic relationships amongst selected *Plesionika* (Decapoda: Pandalidae) from the Northeast Atlantic and Mediterranean Sea. *Marine Ecology* 34:157-170. doi: 10.1111/j.1439-0485.2012.00530.x.

2014

Aarbakke, O.N.S., A. Bucklin, C. Halsband, and F. Norrbin. 2014. Comparative phylogeography and demographic history of five sibling species of *Pseudocalanus* (Copepoda: Calanoida) in the North Atlantic Ocean. *J. Exp. Mar. Biol. Ecol.* 461: 479-488

Blanco-Bercial, L., A. Cornils, N.J. Copley, and A. Bucklin. 2014. DNA barcoding of marine copepods: assessment of analytical approaches to species identification. *PLOS Currents Tree of Life* [2014 June 23]

Cornils, A. 2014. Non-destructive DNA extraction for small pelagic copepods to perform integrative taxonomy. *J. Plankton Res.* doi:10.1093/plankt/fbu105

Pearman, J.K., M.M. El-Sherbiny, A. Lanzén, A.M. Al-Aidaros, and X. Irigoien. 2014. Metagenetic Analysis of Red Sea Zooplankton Diversity. *Front. Marine Sci.* doi: 10.3389/fmars.2014.00027

Smolina, I., S. Kollias, M. Poortvliet, T.G. Nielsen, P. Lindeque, C. Castellani, E.F. Møller, L. Blanco-Bercial, and G. Hoarau. 2014. Genome- and transcriptome-assisted development of nuclear insertion/deletion markers for *Calanus* species (Copepoda: Calanoida) identification *Molec. Ecol. Res.* doi: 10.1111/1755-0998.12241

Torres, A.P., F. Palero, A. dos Santos, P. Abelló, E. Blanco, A. Boné, and G. Guerao. 2014. Larval stages of the deep-sea lobster *Polychaetes typhlops* (Decapoda, Polychelida) identified by DNA analysis: morphology, systematic, distribution and ecology. *Helgoland Marine Research*, 68(3): 379-397. doi: 10.1007/s10152-014-0397-0

2015

Albaina, A., X. Irigoien, U. Aldalur, G. Boyra, M. Santos and A. Estonba. 2015. Macrozooplankton predation impact on anchovy (*Engraulis encrasicolus*) eggs mortality at the Bay of Biscay shelf break spawning centre. *ICES J. Mar. Sci.* 72, 1370-1379

Albaina, A., X. Irigoien, U. Aldalur, U. Cotano, M. Santos, G. Boyra and A. Estonba. 2015. A real-time PCR assay to estimate invertebrate and fish predation on anchovy eggs in the Bay of Biscay. *Progr. Oceanogr.* 131, 82-99.

Cornils, A. and B. Wend-Heckmann. 2015. First report of the planktonic copepod *Oithona davisae* in the northern Wadden Sea (North Sea): Evidence for recent invasion? *Helgol Mar Res.* doi: 10.1007/s10152-015-0426-7

Viñas, M.D., L. Blanco-Bercial, A. Bucklin, H. Verheye, J. Guilherme, F. Bersano and S. Ceballos. 2015. Phylogeography of the copepod *Calanoides carinatus* s.l. (Krøyer) reveals cryptic species and delimits *C. carinatus* s.s. distribution in SW Atlantic Ocean. *J. Exp. Mar. Biol. Ecol.* 468: 97-104

5 Progress report on ToRs and Workplan

ToR (a) Expand membership of WGIMT

The WGIMT membership has grown from a total of 22 members as of March, 2013 to a total (as of March 20, 2015) of 36 members from 15 countries (Annex 1). A WGIMT goal is to continue to expand membership by individual invitations; suggestions can be sent to Ann Bucklin. New members are welcome; we particularly encourage those who develop and use molecular and/or morphological approaches to taxonomic analysis of zooplankton. Membership in WGIMT extends to scientists working in any ocean region, in addition to the ICES region.

ToR (b) Develop a web platform for promotion and exchange of relevant scientific information

Discussion allowed review of progress to date and next steps in the several existing elements of the WGIMT web portal (morphological, molecular, and optical), as well as new elements to be developed. Primary responsibility for ToR (b) is Todd O'Brien, with assistance from WGIMT members (as indicated for each section, below). Todd reported that progress on further development of the WGIMT web portal has been made primarily in three areas: Molecular methods, Photo gallery, and Literature database, as described in detail below.

Morphological methods (Claudia Castellani, Elaine Fileman, Antonina dos Santos)

Claudia updated the group on her efforts to support enhanced capacity and expertise in morphological taxonomic identification of zooplankton, including progress on a comprehensive book on the subject, *The Plankton Handbook* (C. Castellani and M. Edwards, Eds., Oxford University Press).

The group discussed copying the URL links on the CMarz website (<http://www.cmarz.org>) with direct access to taxonomic guides, keys, monographs, and reference papers (all off-copyright). Todd suggested WGIMT choose to organize the material by topic areas as well as linking to portions of the CMarz website rather than reproducing the entire website. Ann asked that Grazia, Antonina, and Claudia review the CMarZ page and make recommendations to Todd about which links should be copied or moved.

Discussion ensued about whether to include advice and recommendations about best practices and most useful resources on the WGIMT web portal. Ann said that last year

the group decided to stay with information, rather than advice – but this could be revisited. Jasmine said each individual should be able to make their own decisions. Antonina thought that need to warn people of use the infor-



mation carefully. Ann suggested that we focus first on decisions about what materials to move over to the WGIMT portal, and consider whether or not to add advisory comments at some future date. Antonina suggested adding a description of laboratory techniques for taxonomic analysis of zooplankton. She has a manual, which will be available on a website describing apparatus and supplies needed, including dissecting stereomicroscope, photo and *camera lucida* adaptors. Grazia agreed that this method is very useful; she showed *camera lucida* drawings done by a student. Todd thanked Elaine for sending photos of plankton as well as action photos of people working in the lab (an example is included here) or at sea; he requested that WGIMT members make every effort to provide additional photos. Todd also requested information and URL links to keys for morphological identification of zooplankton, so these new links can be added to the web portal. Elaine provided several new links:

Conway, D.V.P. (2012). Identification of the copepodite developmental stages of twenty-six North Atlantic copepods. Occasional Publications. Marine Biological Association of the United Kingdom (21 revised edition) 35p.
<http://www.mba.ac.uk/nmbi/publications/occpub/occasionalpub21revised.htm>

Conway, D.V.P. (2012) Marine Zooplankton of southern Britain. Part 1: *Radiolaria, Heliozoa, Foraminifera, Ciliophora, Cnidaria, Ctenophora, Platyhelminthes, Nemertea, Rotifera and Mollusca*. A.W.G. John (ed.) Occasional Publications. Marine Biological Association of the United Kingdom (25) 138p. <http://www.mba.ac.uk/nmbi/publications/occpub/occasionalpub25.htm>

Conway, D.V.P. (2012) Marine Zooplankton of southern Britain. Part 2: *Arachnida, Pycnogonida, Cladocera, Facetotecta, Cirripedia and Copepoda*. A.W.G. John (ed.) Occasional Publications. Marine Biological Association of the United Kingdom (26) 163p.
<http://www.mba.ac.uk/nmbi/publications/occpub/occasionalpub26.htm>

Optical methods (Mark Benfield and Astthor Gislason)

Mark said he plans to base the WGIMT reference library of images on SCOR WG130, which has produced many excellent images. There are a number of important issues to be considered, including: 1) whether or not to include voucher specimens, DNA barcodes, *in situ* images; and 2) recommendations for image resolution, specimen orientation, collection method, and preservation. WG130 developed gold, silver, and bronze standards for these parameters (details available from Mark), which are instrument-specific: Gold: Species ID, DNA barcode, voucher specimen, high-resolution microscopy; Silver: Species ID, voucher specimen, high-resolution microscopy; Bronze: Species ID, voucher specimen; and Lead: Species ID.

Mark recommended reference training sets and design of a QA/QC (quality assurance / quality control) process. He said this is easy if there is a DNA barcode, but otherwise needs a consensus-based approach, with review of datasets at some set frequency; and ratings or standards for the taxonomic expertise of the people making identifications, or other means of indicating confidence in the accuracy of the species ID. Pennie noted that published protocols (see Cornils, 2014) are available for barcoding crustaceans and retaining the exoskeleton. Todd asked about groups doing this kind of review. Mark said that there was a group in France doing Zooscan image verifications. Grazia suggested comparing ZooScan and photo-microscopic images of specimens. Elvira suggested that multiple images – and orientations - may be needed to ensure identification; she typically

has 10–20 images for each species. Ann reminded the group of earlier discussions about a machine training site; Mark replied that this would take a lot of work, cannot happen overnight; and he does not know how to do the verification.

Todd commented that there is great potential for WGIMT's contributions to optical ID approaches. Ann agreed that the clearinghouse concept is consistent with plans for the WGIMT web portal, which could act as a brokering site for web resources. Todd suggested focusing first on a set of specific taxa. Elaine suggested starting with FlowCam images, which she feels are of good enough quality. Todd requested that Mark and Klaus send him good images. Peter suggested that the optical section might have a tutorial on how to take good pictures of bugs – so-called “tricks of the trade”. He asked about videos of live zooplankton, and Mark replied that there are websites with good videos. Grazia agreed and noted as an example the Plankton Chronicles Project (www.planktonchronicles.org), which has a nice photo gallery and videos that could be linked.

Molecular methods (Silke Laakmann, Astrid Cornils, Ann Bucklin, Pennie Lindeque)

The goal is to provide a comprehensive summary of PCR and sequencing primers and protocols and associated references. Todd displayed a webpage in development (temporary URL) that has a table of primers; he asked for feedback and advice for further development, especially from the WGIMT members assigned to this task. Antonina suggested adding information on PCR protocols, including annealing temperatures, but Pennie said she does not think temperature is needed. Ann suggested a hierarchical arrangement of primers, from group- to species-specific. Peter suggested adding links to the WGZE species information. Grazia suggested focusing WGIMT efforts on groups of particular importance and interest, perhaps starting with the Arthropoda or Crustacea. Pennie reminded the group that it may not be possible to know which primers will work with which taxa: i.e., how “universal” the primers are. Rowena asked whether people would know what forward and reverse primers are; Ann suggested adding notes to indicate primer targets of mitochondrial or nuclear genes.

Ann suggested that there should be a species field, and there ensued discussion on how to implement this. Todd said individual species primers can be found, if searching *Calanus* in general, then all primers for *Calanus* species would come up. We should be able to tag primers to level of specificity. Lidia suggested that a glossary of molecular terms (e.g., amplicon, NGS, barcode, miTAQ) be included in the web portal. Another topic of discussion was whether to include a “comments” field to allow inclusion of more information and any advice and recommendations. Ann said that last year the group had a conversation about being advisory or informative, and the consensus was to stay with information, rather than advice – but this could be revisited.

Overall, a point of consensus was that the goal of the primer table should be to provide access to the scientific literature and assist researchers in finding detailed protocol information in the original publications.

Photo gallery of images of living zooplankton (Elaine Fileman, Ann Bucklin, with assistance from CMarZ Webmaster Nancy Copley, WHOI)

A new feature of the WGIMT portal is a photo gallery of high-quality images of living zooplankton. Software will be selected to allow posting and organizing the images for easy access and viewing; images will be cross-linked to WGIMT/WGZE taxonomic data-

base entries (e.g., WGZE time series, geographic maps, and biovolume analyses). Photo galleries from the Census of Marine Zooplankton (www.cmarz.org) have been partially re-established on the WGIMT web portal. Todd has now turned it into a loose teaching laboratory. Each species can have multiple files that have distribution, environmental information, and optical images, and the primer if available. Mark thinks a library might be used to find a similar image to one just taken to figure out what species it is using google search image. Species is a child of a genus and if a person pulls up *Calanus*, then all *Calanus* species will also be shown. Currently, Todd has 60 images implemented, organized in a systematic hierarchical arrangement based on the taxonomic information on the WoRMS (World Registry of Marine Species) and AlgaeBase taxonomic systems.

Mark asked how the species identifications for the photos could be quality controlled. Todd replied that he tried to restrict images to those specimens identified by an acknowledged expert in the group. Ann asked about ensuring that each image included photo credits and also acknowledgement for the person who identified the specimen. Each image should have additional information (metadata) to allow access of the original photo. Claudia asked about copyright restrictions for the images. Ann said that all Census of Marine Life photos are in the public domain (the Sloan Foundation did not allow copyrighting of photos, but required use of photo credits). Todd suggested that there be clear indication of who to contact to request use of photos. Additional suggestions included inclusion of a scale bar and longitude and latitude coordinates for each image.

Elaine asked for a “hit counter” to record number of views for the web page; Todd said he can do this. Grazia wanted to have preserved animal images also in the photos. Todd said could have live photos, dead photos, drawings, optical in situ images. Claudia said that SAHFOS has images of preserved specimens that might be used on this web sites. Ann suggested these be made available as a separate photo collection.

For validation of species ID, Todd said he could set up the site so that anyone could upload an image, which could then be referred to a committee for validation. Ann was against the option of uploading automatically; people should be required to send an email with a submission request. For implementation of the photo gallery, Todd said he can provide image search options (sorting by submitter, species name, location, etc.). The system is built and can be available by next year. Todd gave a demonstration of how the web site would work, but cautioned that not all links will work. Grazia suggested a poster on the WGIMT web portal at the 6th ZPS next year and this was thought a good idea.

Literature database (Todd O'Brien)

A new two-pathway online system for scientific literature relevant to WGIMT is being designed and developed by Todd O'Brien. Public access will entail display of a pathway showing only the reference. Password-controlled access, available only to WGIMT members, will also have links to downloadable PDFs of the actual publication. The system will have a generic design to allow application for WGZE, WGPME, and others. A forms-based entry process will be used to reduce the administrator's (Todd) workload.

There is a Reference Library of papers linked to the primer table. This is now just a string of text, with a short reference that can link to a full citation. There are several ways to search: by name; name + publication year; name + publication year + WGIMT category (molecular, morphological, and/or optical, etc.). Todd proposed an uploading form, with

three active areas: 1) paste in full citation; 2) click a category to choose WGIMT category; and 3) provide link to online PDF or upload PDF. Grazia raised the issue of copyrighted papers (PDFs). Everyone agreed that only PDFs without copyright restrictions should be made available via the WGIMT portal. Todd said that access to PDFs with copyright restrictions would have password protection; he said he is very careful about copyright laws. Claudia said pre-publication versions of manuscripts can sometimes be posted without violating copyrights.

Ann asked whether someone will be able to view the entire reference list; Todd replied 'yes' and said list can be sorted in a variety of ways. Ann wanted to be able to identify authors who are WGIMT members; Pennie suggested color-coding the WGIMT author citations; Todd said he could implement this. He is also preparing a reference library for WGZE and other ICES WGs. The libraries will be kept separate. Grazia asked that the form request keywords. Todd said he could implement check boxes with a limited set of key words, but would need WGIMT members to design the list. Papers can have multiple keywords and categories (i.e., check boxes).

WGIMT News (Todd O'Brien)

In 2014, several WGIMT members requested the addition of a "News!" bullet or link on the WGIMT.net homepage. This will allow members to post updates, announce new publications, and share highlights of group members' activities. This feature of the WGIMT web portal is viewed positively, but of less importance than the other features that were the focus of the discussion.

ACTIONS: WGIMT members should provide to Todd the materials necessary to populate the WGIMT web portal. Specific needs in each feature of the portal include:

- 1) Molecular methods: Silke, Astrid, Pennie, and Ann to send feedback to Todd on current version of primer table, including the imbedded references. Add new features (e.g., comments field, glossary of molecular terms) when possible.
- 2) Morphological methods: Claudia, Antonina, and Grazia to review CMarZ website page with URL links and make suggestions about whether to link to the page or copy the links (and if the latter, which ones). All WGIMT members to send URL links to useful taxonomic materials, keys, and references, with PDF reprints if not copyrighted.
- 3) Optical methods: Mark and Klaus to send Todd sets of images to launch this feature of the portal; Mark to send Todd URL for Gaby Gorsky's website; Grazia to send Todd URLs with videos of zooplankton.
- 4) Photo gallery: WGIMT to submit an abstract for an ICES ZPS 2016 poster showcasing the WGIMT photo gallery and web portal. WGIMT members to send to Todd photos of living plankton and people engaged in zooplankton research.
- 5) Literature database: Once the forms-based entry process is operational, all WGIMT members should upload citations and other information about articles published on WGIMT-related topics, and upload PDFs without copyright restrictions.

ToR (c) Initiate and support provision of standards, training materials, and taxonomy workshops

SAHFOS–MBA Zooplankton Taxonomy Workshop – 2015

Claudia Castellani presented details of the marine Crustacean Zooplankton Workshop that SAHFOS are running from 22 June – 26 June 2015. The workshop is aimed at people who already have some knowledge of marine zooplankton identification. It will be an interactive training course covering classical morphological identification and molecular techniques. There is more information on the SAHFOS website at <http://www.sahfos.ac.uk/zooplankton-2015.aspx>. There will be also a lecture on external quality control for zooplankton identification from the National Marine Biological Analytical Quality Control Scheme (NMBAQC). The deadline for applications has been extended to the 10 April as Claudia has applied to NERC for an advanced training grant to support 10 early career scientists/students. Claudia will hear the outcome of this application on 30 March. So far there have been 34 applicants but not all are able to pay the fees. The criteria for selection would be a good mixture of taxonomic identification skills, with a clear desire to improve, but not beginners. There was a discussion about the right mix of skills needed in the participants. Maria Grazia Mazzocchi thought that if the skills were too heterogeneous it could cause problems for the teachers. Ann Bucklin felt that a mix of students could sometimes be very dynamic, with the more expert students helping others. Claudia Castellani stated that at the last workshop in 2006 they had a mixture of technicians, scientists and students and it had worked well. This one would also be open to all interested in improving their taxonomic skills. Information about the students' interests and research will be shared with course lecturers.

The next discussion was about what types of samples students could bring to the workshop, and whether this information would be supplied to the students. Claudia Castellani initially stated that it was up to the student, and that she assumed that samples being brought would be for morphological analysis only. Rowena Stern noted that certain preservatives could be subject to travel restrictions and Claudia Castellani stated that SAHFOS deals with the transportation of ethanol and formaldehyde preserved biological material globally and could provide advice to the students. Ann Bucklin asked for confirmation that samples would just be for taxonomy and there would be no DNA extraction on students own samples. Claudia Castellani felt that it depended on what the student wanted to learn from their sample, and that once the participants had been selected then that sort of information could be gathered. Rowena Stern asked whether they could send samples ahead of the workshop so that DNA extraction could be carried out on 10-15 specimens that had been pre-identified. Ann Bucklin suggested that the students could make a case for their sample being selected and the DNA could be extracted from the top 10.

ICES Zooplankton Identification Leaflets Updates

In conjunction with the WGZE, Antonina Dos Santos and Claudia Castellani offered to lead efforts to update the ICES Zooplankton Identification Leaflets. WGZE will propose the two individuals to ICES as new editors of the documents, which are currently stored on the ICES website. Among the challenges in this effort is that access to the leaflets is limited because of out-of-date PDF file formats. Good access to existing PDFs will be re-

quired; permission is needed from ICES to update and correct errors discovered in some of the keys.

Since revising all the keys will be a huge effort, it is proposed to start on the most common species in the ICES areas and the Mediterranean, and request assistance from taxonomic experts. Suggestions from WGIMT members are welcome for taxonomic experts who can be engaged to participate. Also, there are currently no impact factors associated with these publications; the group suggested that these be designated as data publications and be assigned a DOI, so they can be cited and more easily accessed. Another issue may be copyright of the leaflets and whether this can be transferred to the WGZE website.

ACTION: WGIMT members are encouraged to develop proposals for future ICES Taxonomy Workshops. Draft proposals can be circulated to WGIMT members for discussion and recommendations via email or virtual meetings.

ACTION: WGIMT to continue to support WGZE recommendation to ICES that Claudia Castellani and Antonina dos Santos be named as editors of the ICES Zooplankton Identification Leaflets.

ToR (d) Promote and encourage the continuing integration of molecular and morphological taxonomy

WGIMT members discussed plans to propose special sessions on integrative taxonomy at upcoming international conferences. Previously, the group organized special sessions at the 2014 Ocean Sciences Meeting (Honolulu, USA) and ICES 2013 Annual Science Conference (Reykjavik). The group noted that the ICES ASC 2013 special theme session was successful at drawing in participation. The group discussed an ICES ASC 2015 Theme Session to be co-convened by WGIMT member Antonina dos Santos. The decision was made not to propose a theme session for the ICES 2016 ASC, since it would compete with a session approved for the ICES/PICES 2016 Zooplankton Production Symposium convened by Ann Bucklin (ICES) and Ryuji Machida (PICES).

ACTION: WGIMT members are encouraged to be vigilant of any opportunities to organize and convene theme sessions at upcoming national and international meetings and conferences.

ToR (e) Advise on the implications of developments for marine science and management

Ann Bucklin introduced ToR (e) and stated that there is no Year 1 deliverable for this ToR, given the change in focus and the new multi-year deliverables. The discussion focused on considering this new focus on metagenetic (also called metabarcoding) analysis and specifying appropriate and useful WGIMT deliverables. Suggestions from all WGIMT members were sought.

Jon Corell gave a presentation titled, *Zooplankton diversity comparison using different metabarcoding approaches*, describing work to evaluate how different methods of DNA extraction, primer selection, and metabarcoding approaches on microzooplankton samples can lead to different estimates of diversity. This work will also be carried out on mesozooplankton samples in the near future. Rowena Stern asked whether Jon had been able

to normalize the arthropod 18S rRNA copies, since some species have large number of copies of this gene. Jon thought it was possible he had. Naira Rodriguez-Ezpeleta added that COI has the same difficulties of high and highly-variable copy numbers, but 18S rRNA has the advantage that the copy number is stable, so the bias is knowable. Ann Bucklin stated that there are similar problems with eukaryotes; she described a study by Aitor Albaina Vivanco that showed the challenges of making inferences with metagenetics because of variable gene copy numbers.

Naira Rodriguez-Ezpeleta then presented an update on developments from AMBI (AZTI's Marine Biotic Index), which is developing biodiversity metrics based on metagenetics or metabarcoding. Current work is looking at whether DNA extraction methods and different PCR primers/conditions can affect results, and what the magnitude of the effects are.

Preliminary results using one 18S rRNA primer pair indicate that DNA extraction methods may impact results, but not PCR protocol conditions, for which replicates give similar results. Naira promised to send published results when available; she will be presenting at the ICES 2015 ASC, Theme Session D, "New approaches to measure and assess biodiversity", and expects to publish a methods paper in the near future.

Ann Bucklin then gave a presentation prepared by Aitor Albaina Vivanco, which first reviewed recent papers on comparing taxonomic analysis using metabarcoding and morphological (microscopic) assessments. A second focus was on prospects for quantification of taxa using amplicon sequencing of the V9 hypervariable region of 18S rRNA, showing that variable gene copy numbers present significant challenges for quantification. Metagenetics is demonstrating excellent capacity for detection and discrimination of taxa, but quantification remains a challenge. The more similar the taxa that are the focus of the study, the better the prospects for quantification. For a very taxonomically diverse group - such as marine metazoan zooplankton - quantification may remain problematical.

Naira Rodriguez-Ezpeleta followed the presentation with a statement that she was doubtful that metagenetics would ever be able to provide accurate quantification of abundance of zooplankton species, although biomass estimates may be possible. Also, abundances of certain calibrated species may be possible, but not species in completely unknown mixes.

Ann Bucklin suggested that it might be useful at this point for the group to discuss specific advice to ICES, consistent with a WGIMT ToR (e) Year 2 deliverable (i.e., report via SSGEPD/ACOM EGs). Naira Rodriguez-Ezpeleta told the group that WGAGFM ToR (c) from 2013 was to examine the potential of metagenetics in the implementation of ecosystem management in the context of the Marine Strategy Framework Directive (MSFD). Ann suggested that WGIMT should reach out to WGAGFM via Naira Rodriguez-Ezpeleta and Aitor Albaina Vivanco, who are members of both WGIMT and WGAGFM, to discuss the applications of metagenetics. Ann felt that the group needs to be careful about building expectations that can't be met. Naira wondered whether it might be possible to recommend a new ToR in common between the EGs. Naira also mentioned a current 2015–2017 WGAGFM ToR to review and assess the utility of molecular techniques to evaluate disease and parasite spread from transferred seafood into wild populations.

Maria Grazia Mazzocchi asked whether there also was any focus on symbionts or viruses, since they can't be detected by other methods. Naira replied that the focus was mainly on parasites that had an impact on human health, but she will circulate the ToR to the group. Ann Bucklin stated that WGIMT is focused on biodiversity assessment, but thought it would be worthwhile asking about complementary areas of interest with WGAGFM.

Rowena Stern noted that the Working Group on Phytoplankton and Microbial Ecology (WGPME) had done a review of methodology intended to promote standardization of methodology, which may overlap with the WGIMT goals. She suggested that WGIMT seek some collaboration on this point with WGPME.

ACTION: WGIMT will recommend a joint ToR with WGAGFM related to examining the potential of metagenetics for biodiversity assessments and other parameters related to the implementation of ecosystem management in the context of the Marine Strategy Framework Directive (MSFD).

ACTION: WGIMT will recommend coordination with WGPME, including perhaps a joint ToR, for review and evaluation of methodologies used for metagenetic analysis of plankton, with the specific goal of facilitating development of standardized protocols for applications in fisheries management and ecosystem assessment.

ToR (f) Cooperate with WGITMO and WGBOSV to encourage and facilitate application of molecular protocols for detection and identification of introduced and transported species in ballast water

Maiju presented progress with AquaNIS alien species database which is now open and available to everybody, and can be used to search alien species and acquire information, including molecular links added to species fact sheets. To properly address research questions concerning the spread and origin of NIS using molecular approaches will require external money. Collaborative research proposals could be planned for the future work. Naiara Rodriguez-Ezpeleta reported that they have been awarded an Intra-European Training network project (AQUAINVAD_ED) that provides money for training PhD students on alien species detection in several environments; AZTI will particularly work in ballast water. Naiara has a PhD student starting in September as part of a 4 year project on ballast water in the Bay of Biscay. This work cuts across WGIMT, WGBOSV, and WGITMO mission areas, and could lead to the possibility of applying to a larger project, maybe an EU life project if anyone is interested.

Discussions followed on how to go forward with this ToR. As WGITMO and WGBOSV met at the same time as WGZE, Maiju was unable to attend, therefore we are unsure of the results of their discussions. However, it seems that Naiara's Bay of Biscay work will make perfect progress for this ToR. Ann asked if Naiara would like to formalise an agreement on this. Naira provided more information about the project, which will start July 2015. Samples will be collected from ballast water to analyse morphologically and also with molecular tools. Naiara and her student could update WGIMT on their progress with this work at the next annual meeting in 2016. It was proposed that we need a target list of top priority invasive species – ideally zooplankton – that WGIMT should focus efforts to ensure public availability of DNA barcodes. Ann's recommendation was to ask WGBOSV and WGBITMO to provide WGIMT with a prioritized list of invasive

species by region and make suggestions of any preferences for our pilot project that we are proposing to carry out for them. For instance, we may decide to select a region of particular interest. WGIMT should also make sure the other EGs are aware of Naiara's project in the Bay of Biscay.

Discussion about the definition of an invasive species, since this can change from region to region, and whether we should focus on invasive species that are now well-established and play an important role in the ecosystem. Accurate lists exist for all regions, but we should concentrate on those invasive species that are most likely to spread further. Naiara and her students may perhaps help facilitate communication and coordination between WGIMT and WGBOSV-WGITMO, including participation in the 2016 annual meetings for both EGs.

ACTION: WGIMT will request from WGBOSV and WGITMO prioritized lists of invasive (zooplankton) species by region, including any suggestions and guidance for the proposed pilot project on DNA barcoding of invasive species in the ICES area. WGIMT will assist with identifying funding for barcoding and ideally WGIMT members will be able to provide DNA barcode sequences.

ACTION: WGIMT will ensure that WGBOSV and WGITMO members are aware of Naiara Rodriguez-Ezpeleta's new project, AQUAINVAD_ED, which will provide training for PhD students on alien species detection in several environments.

ACTION: One or more members of WGIMT will join the WGBOSV/WGITMO annual meeting in 2016, schedules and travel funding permitting. WGBOSV/WGITMO members will be invited to participate in the 2016 WGIMT annual meeting.

ToR (g) Publish peer-reviewed articles on diverse aspects of integrative (morphological and molecular) taxonomy of zooplankton

WGIMT has a goal – consistent with ICES guidance, as we understand it – to publish in the peer-reviewed scientific literature. Recent publications by WGIMT members on topics central to the WGIMT mission more than meet this goal. WGIMT members are encouraged to upload PDFs of publications to the WGIMT share point. Pennie Lindeque presented an overview of papers published by WGIMT members 2013–2015. PDF files for these papers have been posted to the ICES WGIMT SharePoint. (See publication list, above.)

Review article on integrative taxonomic approaches

Given the fast pace of progress in metagenetic analysis of marine planktonic assemblages, a comprehensive review article may have a very short shelf-life. Therefore, it was decided to develop a "position paper" that discusses the promise of metagenetics for analysis of biodiversity, rapid assessment of impacts of climate change, and applications for fisheries management and ecosystem assessments. A short communication article (approximately 2000 words) might focus on the need for a barcode reference library, which supports the primary WGIMT mission of integrative morphological – molecular taxonomic analysis.

ACTION: Once the forms-based entry process for the Literature Database section of the WGIMT web portal is operational, all WGIMT members should upload citations and oth-

er information about articles published on WGIMT-related topics, especially papers for which they are a co-author) and upload PDFs without copyright restrictions.

ACTION: WGIMT members should upload PDFs of articles published on WGIMT-related topics (including especially any papers for which they are a co-author) to the folder on ICES WGIMT SharePoint.

ACTION: Ann Bucklin will lead efforts to prepare a multi-authored manuscript on meta-genetic analysis of zooplankton biodiversity and the need for a reference DNA barcode database. Target is publication as a Horizons article in the *Journal of Plankton Research*. Ann Bucklin will query the WGIMT members to identify individuals interested in being on the writing team, which would begin manuscript preparation as soon as practicable.

6 Revisions to the Work Plan and Justification

ToR (c) Initiate and support provision of standards, training materials, and taxonomy workshops

Future of Integrative Taxonomy: In 2013, Janna Peters, Jasmin Renz, and Astrid Cornils proposed an ICES Taxonomy Workshop (see abstract below), which they requested by forwarded to SSGEPD and SCICOM for consideration for ICES support and funding.

“Morphologically-based methods for species identification are increasingly combined with new methodologies in the field of integrated taxonomy and applied in ecological research, e.g. monitoring and biodiversity research, time series analyses, and assessment of marine communities. This workshop aims to review and discuss the combination and applicability of these approaches. Case studies focusing on integrated taxonomical and ecological research of marine organisms will be presented by invited experts and participants. Furthermore, this workshop will serve as platform to initiate future networking between specialists from different disciplines. WGIMT members have the expertise in both, morphological and molecular taxonomy as well as strong ecological backgrounds, and are thus able to evaluate the future potential of the different approaches.”

A WGIMT recommendation was made and reviewed by SCICOM, which indicated their support and requested an official resolution. SCICOM expressed interest in sponsoring the workshop, but ICES would not provide funding. At the 2014 WGIMT meeting, consideration was given to linking the workshop to the 2016 ICES Zooplankton Production Symposium, which will be held in Bergen, Norway (May, 2016). This year, Jasmin Renz updated the group that since no funding had been secured through either ICES or the German Science Foundation, and since funding for key personnel was also uncertain, further planning on this workshop concept must be indefinitely delayed.

7 Next meetings

WGIMT 2015 annual meeting: The group expressed continued enthusiasm for meeting in association with WGZE. WGZE has again extended an invitation for the 2016 meeting in Lisbon, Portugal. The group would like to meet for one day, either prior to or immediately following the WGZE meeting. The group might also schedule additional short meetings that could take place throughout the WGZE meeting and / or suggest a half-day shared meeting with WGZE to discuss ToRs of shared interest and concern.

Additional meetings: The group suggested a recommendation to WGIMTO/WGBOSV that one or more members from WGIMT participate in the WGMTO/ WGBOSV 2016 annual meeting, which has not yet been announced.

Annex 1: List of participants

Of 36 WGIMT members, 16 members participated in the 2015 annual meeting in person (Y in the right-hand column); one additional member joined via teleconference (V).

	Name	Function	Country	2015
1	Aitor Albaina Vivanco	Chair-invited Member	Spain	
2	Amy Maas	Chair-invited Member	United States	
3	Ann Bucklin	Chair	United States	Y
4	Antonina dos Santos	Chair-invited Member	Portugal	Y
5	Arantza Iriarte	Chair-invited Member	Spain	Y
6	Astrid Cornils	Chair-invited Member	Germany	
7	Asththor Gislason	Chair-invited Member	Iceland	Y
8	Christina Augustin	Chair-invited Member	Germany	
9	Claudia Castellani	Chair-invited Member	United Kingdom	Y
10	Dorte Bekkevold	Member	Denmark	
11	Einar E. Nielsen	Member	Denmark	
12	Elaine Fileman	Chair-invited Member	United Kingdom	Y
13	Elvire Antajan	Chair-invited Member	France	Y
14	Hildur Pétursdóttir	Chair-invited Member	Iceland	
15	Janna Peters	Chair-invited Member	Germany	
16	Jasmin Renz	Chair-invited Member	Germany	Y
17	Kathryn Cook	Chair-invited Member	United Kingdom	Y
18	Leocadio Blanco-Bercial	Chair-invited Member	United States	
19	Lidia Yebra	Chair-invited Member	Spain	Y
20	Maiju Lehtiniemi	Chair-invited Member	Finland	Y
21	Maria Alexandra Chicharo	Chair-invited Member	Portugal	
22	Maria Grazia Mazzocchi	Chair-invited Member	Italy	Y
23	Mark Benfield	Chair-invited Member	United States	Y
24	Naiara Rodriguez-Ezpeleta	Chair-invited Member	Spain	V
25	Panagiotis Kasapidis	Chair-invited Member	Greece	
26	Pennie Lindeque	Chair-invited Member	United Kingdom	Y
27	Peter Wiebe	Chair-invited Member	United States	Y
28	Piotr Margonski	Chair-invited Member	Poland	
29	Robertas Staponkus	Member	Lithuania	
30	Sanna Majaneva	Chair-invited Member	Finland	
31	Sigrun Jonasdottir	Chair-invited Member	Denmark	
32	Silke Laakmann	Chair-invited Member	Germany	
33	Todd D. O'Brien	Chair-invited Member	United States	Y
34	Uwe Piatkowski	Chair-invited Member	Germany	
35	Vijayalakshmi R. Nair	Chair-invited Member	India	
36	Xabier Irigoien	Chair-invited Member	Saudi Arabia	

Annex 2: Agenda

Annual Meeting 20 March 20 2015

Meeting place: Plymouth Marine Laboratories, Plymouth UK

8:30 COFFEE and TEA

9:00 Self-Introductions by WGIMT members

9:15 ToR (a) Expand membership of WGIMT

Expected Deliverable(s): WGIMT will include experts in both morphological and molecular taxonomy for major zooplankton groups; 2 members in common with ACOM EGs (Year 1). WGIMT member(s): Ann Bucklin

9:30 ToR (f) Cooperate with WGITMO and WGBOSV to encourage and facilitate application of molecular protocols for detection and identification of introduced and transported species in ballast water

Expected Deliverable(s): Define (Year 1), carry out (Year 2), and publish (Year 3) results of collaborative activities with WGITMO-WGBOSV. Participate in WGITMO-WGBOSV annual meetings (Years 1,2,3). Provide identifying DNA sequences for invasive species listed on AquaNIS (Year 2). WGIMT member(s): Maiju Lehtiniemi

10:30 ToR (b) Develop a web platform for promotion and exchange of relevant scientific information

Note: There will be a BREAK during 11:00 – 11:15

Discussion during the 2014 meeting described plans for the organization and population of the WGIMT web portal, including morphological, molecular, and optical sections, as well as new elements to be developed. Primary responsibility for ToR (b) is Todd O'Brien with assistance from WGIMT members as indicated following.

Expected Deliverable(s):

A) WGIMT.net web portal designed, established (Year 1) and fully populated (Year 2). WGIMT member(s): Todd O'Brien

B) Morphological methods: Information and URL links to keys for morphological identification of zooplankton. WGIMT member(s): Claudia Castellani, Elaine Fileman, Antonina dos Santos

C) Optical methods: Included in Morphological Methods section or updated. WGIMT member(s): Mark Benfield, Todd O'Brien

D) Molecular methods: A comprehensive summary of PCR and sequencing primers and protocols and associated references. WGIMT member(s): Ann Bucklin, Astrid Cornils

E) Photo gallery: High-quality images of living zooplankton; photo galleries from the Census of Marine Zooplankton (www.cmarz.org) will be migrated. WGIMT member(s): Todd O'Brien

F) Literature database: A new two-pathway online system for scientific literature relevant to WGIMT goals. WGIMT member(s): Todd O'Brien

G) WGIMT News: Members will be able to post updates, announce new publications, and share highlights of group members' activities. WGIMT member(s): Todd O'Brien

12:00 ToR (c) Initiate and support provision of standards, training materials, and taxonomy workshops

Expected Deliverable(s): SAHFOS-MBA Zooplankton Taxonomy Workshop (2015);

ICES Taxonomy Workshop on: *Future of Integrative Taxonomy* (2016).

WGIMT member(s): Claudia Castellani, Jasmin Renz, Astrid Cornils

12:30 LUNCH (Catered on site)

1:30 ToR (e) Advise on the implications of developments for marine science and management

Expected Deliverable(s): Report via SSGEPD and ACOM EGs on uses of integrative taxonomy (e.g., environmental sequencing or metagenetics) for integrated ecosystem assessment (Years 2,3). Report on uses of metagenetic indicators to WGAGFM (Year 2). WGIMT member(s): Naiara Rodriguez-Ezpeleta, Jon Corell, Aitor Albaina Vivanco (presented by Ann Bucklin), Others

3:00 ToR (d) Promote and encourage the continuing integration of molecular and morphological taxonomy

Special session proposals for ICES ASC 2016; update on ICES ASC 2015 special sessions (SSGEPD session on MSFD); feedback from WGIMT presentation at ICES 2014 SSGEPD-SIBAS session.

Expected Deliverable(s): Organize special sessions at national and international conferences, including Ocean Sciences Meetings (2016), ICES ASC (2016), others. WGIMT member(s): Antonina dos Santos

3:30 BREAK

3:45 ToR (g) Publish peer-reviewed articles on diverse aspects of integrative (morphological and molecular) taxonomy of zooplankton

Expected Deliverable(s): Publish two papers related to WGIMT ToRs (Years 2, 3). Publish review article on integrative taxonomic approaches to characterizing zooplankton communities (Year 2). WGIMT member(s): Pennie Lindeque, Ann Bucklin

4:15 pm Updates and suggestions from WGIMT members

Expected Deliverable(s): Action items, next steps, any new ToRs for WGIMT. WGIMT member(s): Ann Bucklin

5:00 pm ADJOURN

Annex 3: Terms of reference 2014–2017

2013/MA2/SSGEF01 The Study Group on Integrated Morphological and Molecular Taxonomy (SGIMT) will be renamed the Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT), chaired by Ann Bucklin, USA, will work on ToRs and generate deliverables as listed in the Table below.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2014	28 March	Reykjavik, Iceland	Interim report by 15 June to SSGEF	
Year 2015	20 March	Plymouth, UK	Interim report by 15 July to SSGEPD	
Year 2016	March (TBA)	Lisbon, Portugal	Final report by DATE to	

ToR descriptors

	DESCRIPTION	BACKGROUND	SCIENCE PLAN TOPICS ADDRESSED	DURATION	EXPECTED DELIVERABLES
ToR					
a	Expand membership of WGIMT	a) Integrative taxonomy requires experts in both morphological and molecular taxonomic approaches. b,c) Members in common will facilitate coordination between WGIMT and ACOM EGs and help ensure advisory goals are met.	1.1.3, 1.2.1, 1.2.3, 3.1	Year 1	WGIMT will include experts in both morphological and molecular taxonomy for major zooplankton groups; 2 members in common with ACOM EGs. (Year 1).
b	Develop a web platform for promotion and exchange of relevant scientific information	a) Locating and accessing morphological and molecular taxonomic information can be difficult: some classical taxonomic references are out-of-print; molecular data are not released prior to publication. b,c) Easier access to data and information will encourage use of integrative taxonomic approaches.	1.1.3, 1.2.1, 1.2.3, 1.6.1, 3.1	Years 1,2,3	WGIMT.net web portal designed, established (Year 1) and fully populated (Year 2) Specially-designed elements and deep links created for WGAGFM, WGITMO, WGBOSV (Years 2, 3).
c	Initiate and support provision of	a,b) ICES Taxonomy Workshops are very	1.2.1, 1.2.3,	Year 2	ICES Taxonomy Workshop on:

	standards, training materials, and taxonomy workshops	effective in engaging the target audience and ensuring trained technicians and researchers for applications in fisheries and ecosystem management. c) Co-sponsored workshops and meetings with ACOM EGs will provide cross-training and establish organic links between science and advice.			<i>Future of Integrative Taxonomy</i> (2015); <i>SAHFOS-MBA Zooplankton Taxonomy Workshop</i> with added molecular component (2015). <i>Baltic Zooplankton Expert Network</i> with WGITMO (2015).
d	Promote and encourage the continuing integration of molecular and morphological taxonomy	a,b,c) Integrative taxonomy is an emergent field; uses and applications for fisheries and ecosystem management should be explained in high-visibility settings in ICES and other organisations through special sessions	1.2.1, 1.2.3, 1.6	Years 1,2,3	Organize special sessions at national and international conferences: Ocean Sciences Meetings (2014, 2016); ICES ASC (2015).
e	Advise on the implications of developments for marine science and management	b,c) Integrative taxonomy (e.g., 'library' of DNA sequences for accurately-identified species) can provide a foundation for genetic methods for assessing species, diversity and abundance in integrated ecosystem assessments. c) Standardized metagenetic data can fulfill requirements of indicators defined in the Marine Strategy Framework Directive (WGAGFM).	1.2.1, 1.2.3, 1.6	Years 2,3	Report via SSGEPD and ACOM EGs on uses of integrative taxonomy (e.g., environmental sequencing or metagenetics) for integrated ecosystem assessment (Years 2,3). Report on uses of metagenetic indicators to WGAGFM (Year 2).
f	Cooperate with WGITMO and WGBOSV to encourage and facilitate application of molecular protocols for detection and identification of introduced and transported species in ballast water	a,b,c,) Integrative morphological-molecular taxonomic approaches will provide uniquely sensitive and accurate methods for detection of invasive species in natural assemblages and ballast water. Sources of origin and pathways of transport can be inferred from genetic analysis. These advanced will	2.5	Years 1, 2,3	Define (Year 1), carry out (Year 2), and publish results (Year 3) of collaborative activities with WGITMO-WGBOSV. Participate in WGITMO-WGBOSV annual meetings (Years 1,2,3). Provide

		enable and facilitate better enforcement of regulations.			identifying DNA sequences for invasive species listed on AquaNIS (Year 2).
g	Publish peer-reviewed articles on diverse aspects of integrative (morphological and molecular) taxonomy, of zooplankton.	a) Stronger foundation and visibility in primary research literature is needed to establish the field of integrative taxonomy. b) Publication in peer-reviewed literature needed to demonstrate validity of data, protocols, and results for application to fisheries and ecosystem management.	1.1.3, 1.2.1, 1.2.3, 3.1	Years 2, 3	Publish two papers related to WGIMT ToRs (Years 2, 3). Publish review article on integrative taxonomic approaches to characterising zooplankton communities (Year 2).

Summary of the Work Plan

Year 1	Focus on increasing membership (ToR a); design and establish web portal (ToR b). Advise WGAGFM on metagenetic approaches for taxonomic analysis of analysis (ToR e). Define partnership activities with WGITMO and WGBOSV (ToR f).
Year 2	Focus on integrative taxonomy workshops (ToR c). Carry out collaborative activities with WGITMO and WGBOSV (ToR f). Publish overview review article summarizing integrative approaches to zooplankton taxonomy (ToR g).
Year 3	Facilitate, encourage and enable use of integrated morphological and molecular taxonomic analysis of zooplankton in integrated ecosystem assessments in ICES area seas (ToRs d,e,f,g).

Supporting information

Priority:	This Working Group will assist ICES and its Expert Groups with issues related to the development, dissemination and application of taxonomic knowledge and skills in support of Integrated Ecosystem Understanding. Accurate identification of species and characterization of species-level diversity are and will remain foundations of integrated ecosystem assessments of function and state. Integrated taxonomic approaches – including morphological, molecular, optical, and other – may enhance and accelerate progress toward rapid, automatable, and near-real-time identification of species for fisheries and integrated ecosystem assessments; detecting of the impacts of climate change on species diversity, distribution, abundance; and understanding alterations in food web structure and function, and associated biogeochemical cycles. The availability of and need for new technology and techniques in taxonomic analysis make WGIMT's goals and activities important and high priority.
Resource requirements:	The research programs and Expert Group activities that provide input and are stakeholders for this group are already in place. Additional resources required for planned activities may include: 1) effort by an ICES web manager to maintain a web portal with taxonomic information and links.
Participants:	The Expert Group now includes 23 members from 11 countries. Membership

	is expected to grow in near future through engagement of members from partner ICES Working Groups and other scientists with needed expertise and knowledge. The goal is to ensure balance and coverage of varied taxonomic approaches (including morphological taxonomists for the full range of taxonomic groups) and ICES geographic regions.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to ACOM and groups under ACOM:	Cooperative partnerships have been established with WGITMO and WGBOSV as defined in ToR (f); additional activities will be planned and implemented. A recommendation from WGAGFM was accepted and the requested cooperative activities will be carried out.
Linkages to other committees or groups:	WGIMT arose as a Study Group from the WGZE in response to perceived need, meeting in association with WGZE during 2012 and 2013. WGIMT will remain in close partnership with WGZE, while promoting and supporting integrated morphological and molecular taxonomy science for the benefit of other ICES Expert Groups and marine science generally.
Linkages to other organizations:	The work of this group relates to and is connected to a diversity of other projects and organisations, e.g., EU MARBEF, EDIT, GBIF, PESI, GOBI, and others.

Annex 4: Recommendations

RECOMMENDATION	ADDRESSED TO
1. WGIMT recommends that the 2016 meeting be held in association with the WGZE 2016 meeting, which will meet Lisbon, Portugal during March 2016. WGIMT proposes to meet for one day prior to or immediately following the WGZE meeting.	WGZE
2. WGIMT recommends that WGBOSV and WGITMO consider providing lists of top priority invasive species – ideally marine zooplankton – organized by region for DNA barcoding, consistent with our shared ToR [WGIMT ToR (f)].	WGITMO and WGBOSV
3. WGIMT recommends a joint ToR with WGAGFM that will entail examining the potential of metagenetics for biodiversity assessments and other parameters related to the implementation of ecosystem management in the context of the Marine Strategy Framework Directive (MSFD).	WGAGFM
4. WGIMT recommends expanded coordination with WGPME, including perhaps a joint ToR, for review and evaluation of methodologies used for metagenetic analysis of plankton, with the specific goal of facilitating development of standardized protocols for applications in fisheries management and ecosystem assessment.	WGPME